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# THE DOUGLAS-FIR TUSSOCK MOTH PROBLEM IN THE NORTHWEST

## STATUS, IMPACTS, AND ALTERNATIVES FOR 1974

**Prepared by: Interagency Tussock Moth Steering Committee**

**Portland, Oregon**
**December 1973**

The Interagency Tussock Moth Steering Committee was organized in July 1973 to provide coordination among the federal and state agencies having responsibilities for dealing with the tussock moth problem in the Northwest. Agencies represented on this ad hoc committee are as follows:

- U.S. Forest Service:
  - Pacific Northwest Region
  - Northern Region
  - Intermountain Region
  - Pacific Northwest Forest & Range Experiment Station
  - Pacific Southwest Forest & Range Experiment Station
- Oregon State Department of Forestry
- Oregon State University
- Washington State Department of Natural Resources
- Idaho Department of Public Lands
- Nevada Division of Forestry
- Bureau of Indian Affairs
- Bureau of Land Management
- Environmental Protection Agency (Advisory Capacity only)

Public interest in the tussock moth problem is certain to continue, probably for as long as the insect is causing severe damage to western forests. Several reports are already available on this problem and can be obtained from the agencies listed above. In addition, the Steering Committee felt the need to summarize existing information and to provide both public and forest land managers with a report on the current situation – the status of the outbreak, its impacts, and control actions being considered for 1974. This report, primarily in question-and-answer format, is the result. It was prepared from information from several sources and by many individuals. The committee expresses its appreciation for the excellent cooperation and assistance.

Additional copies may be obtained from the Forest Service and state agencies listed above.

# THE DOUGLAS-FIR TUSSOCK MOTH PROBLEM IN THE NORTHWEST

### Status, Impacts, and Alternatives for 1974

## BACKGROUND

The Douglas-fir tussock moth is a destructive, foliage-feeding, native insect which reaches epidemic levels in western forests at irregular intervals. National attention was focused on the insect when severe defoliation of Douglas-fir and true fir forests occurred during 1972 in northeastern Oregon and southeastern Washington. The outbreak continued in 1973; new satellite outbreak areas were discovered; and additional outbreaks were detected in Idaho, Montana, and other areas of Washington. Collectively, these outbreaks, now totaling some 800,000 visibly defoliated acres, are considered to be the most serious of record.

Questions concerning control of the outbreaks have become highly controversial. The application of DDT to forest stands is the only proven method of effectively controlling this insect, but there is considerable public concern about the environmental impacts of the chemical. Virtually all uses of DDT were cancelled in December of 1972. On the other hand, there is much concern about the environmental and economic impacts of defoliation by the moth. Methods of predicting tussock moth population levels and damage are imprecise, so that benefit-cost determinations can be difficult. Because of public concern about impacts of the moth and of DDT, public involvement has been high.

An environmental impact statement was developed by the U.S. Forest Service at the end of the 1972 season, and subsequently the U.S. Department of Agriculture requested the use of DDT in 1973 for the Blue Mountains outbreak, as did the states of Oregon and Washington, the Walla Walla Chamber of Commerce, and Boise Cascade Corporation. All requests for DDT were denied by the Environmental Protection Agency (EPA).

In the summer of 1973, field tests with four chemical insecticides were made on a trial basis. None of these proved adequately effective. Aerial spraying experiments with the natural virus of the tussock moth and a bacterium were also conducted and showed much promise, but additional experimentation and pilot testing are needed before they can be considered for registration and operational use. Consequently, DDT is still the only effective chemical now known should control be undertaken in 1974.

In the fall of 1973, after the insect entered its dormant period in the egg stage, surveys were made to assess the levels of overwintering populations. These surveys show a potential for additional serious defoliation on approximately 649,000 acres in Oregon, Washington, and Idaho.

Detailed assessment of actual need for control in 1974 must await determination of the level of natural virus in the eggs, and the effects of egg parasites, predators, and possible overwintering stresses. Virus levels will be determined by rearing the insect in the laboratory this winter; results will be known in March.

Members of the Interagency Tussock Moth Steering Committee are certain that public interest in the tussock moth will continue. In order to inform the public, existing information has been updated in this question-and-answer report. The following questions have been most frequently asked; the committee has attempted to provide answers by assembling facts from the best information available.

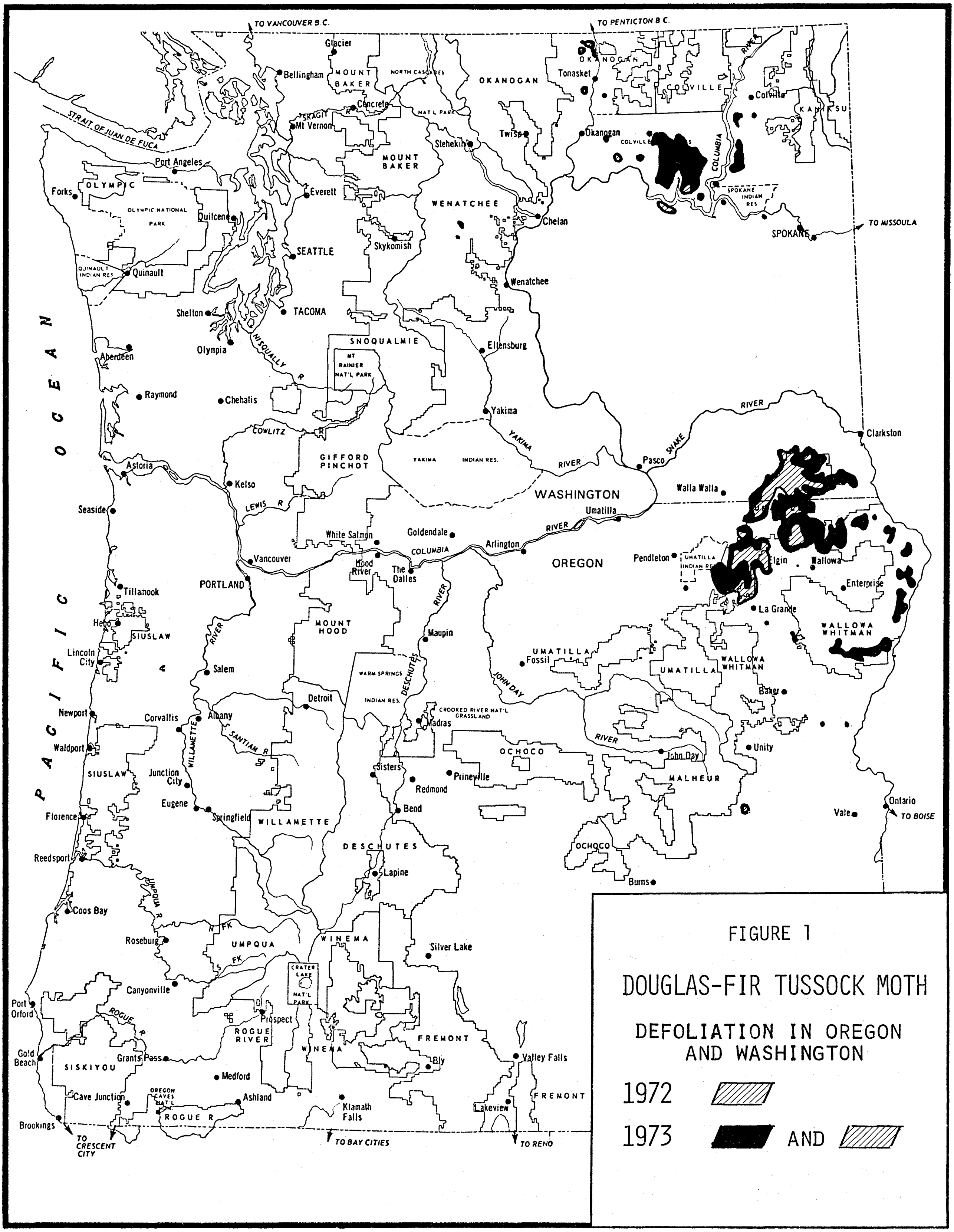



FIGURE 1

DOUGLAS-FIR TUSSOCK MOTH

DEFOLIATION IN OREGON AND WASHINGTON

1972 [hatched]

1973 [solid] AND [hatched]

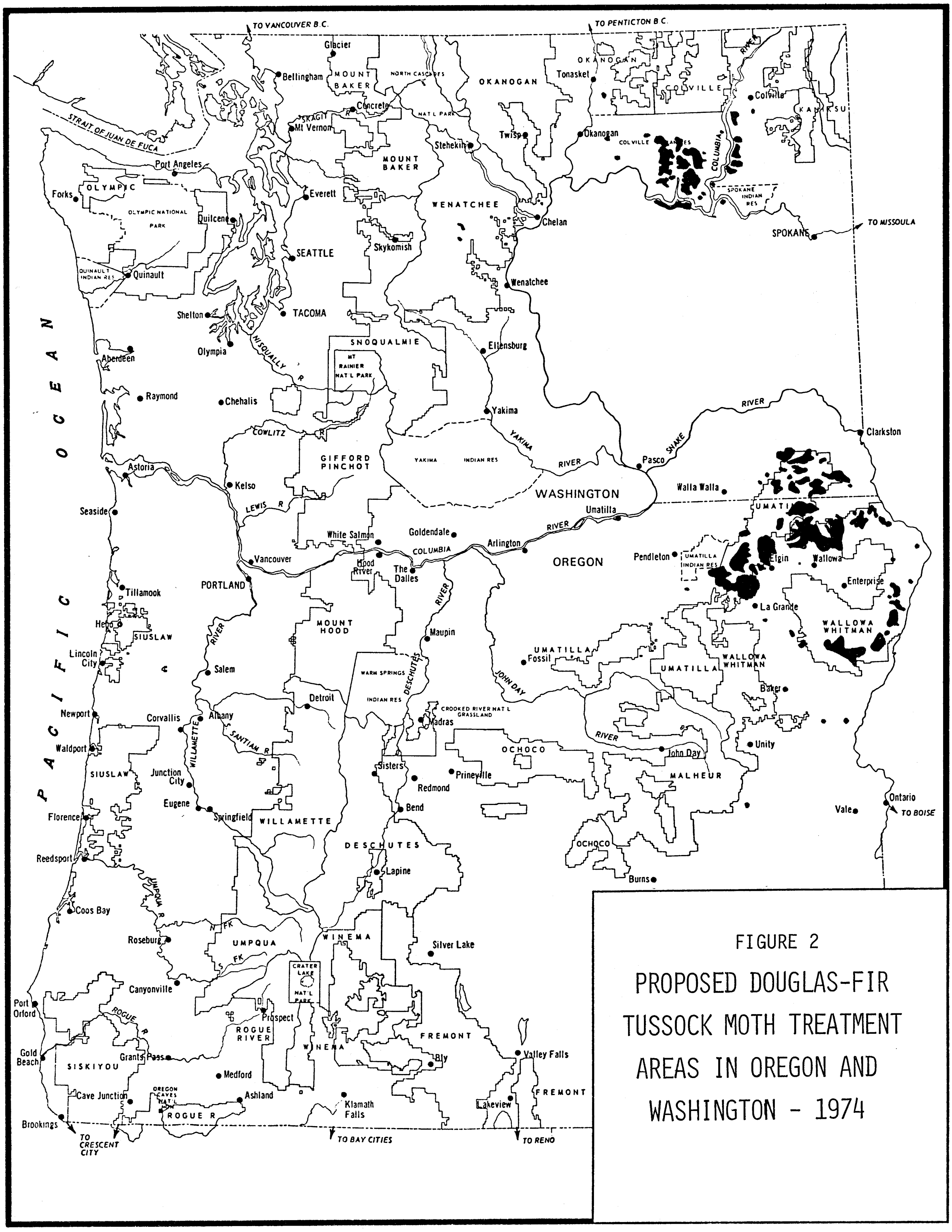



FIGURE 2

PROPOSED DOUGLAS-FIR TUSSOCK MOTH TREATMENT AREAS IN OREGON AND WASHINGTON - 1974

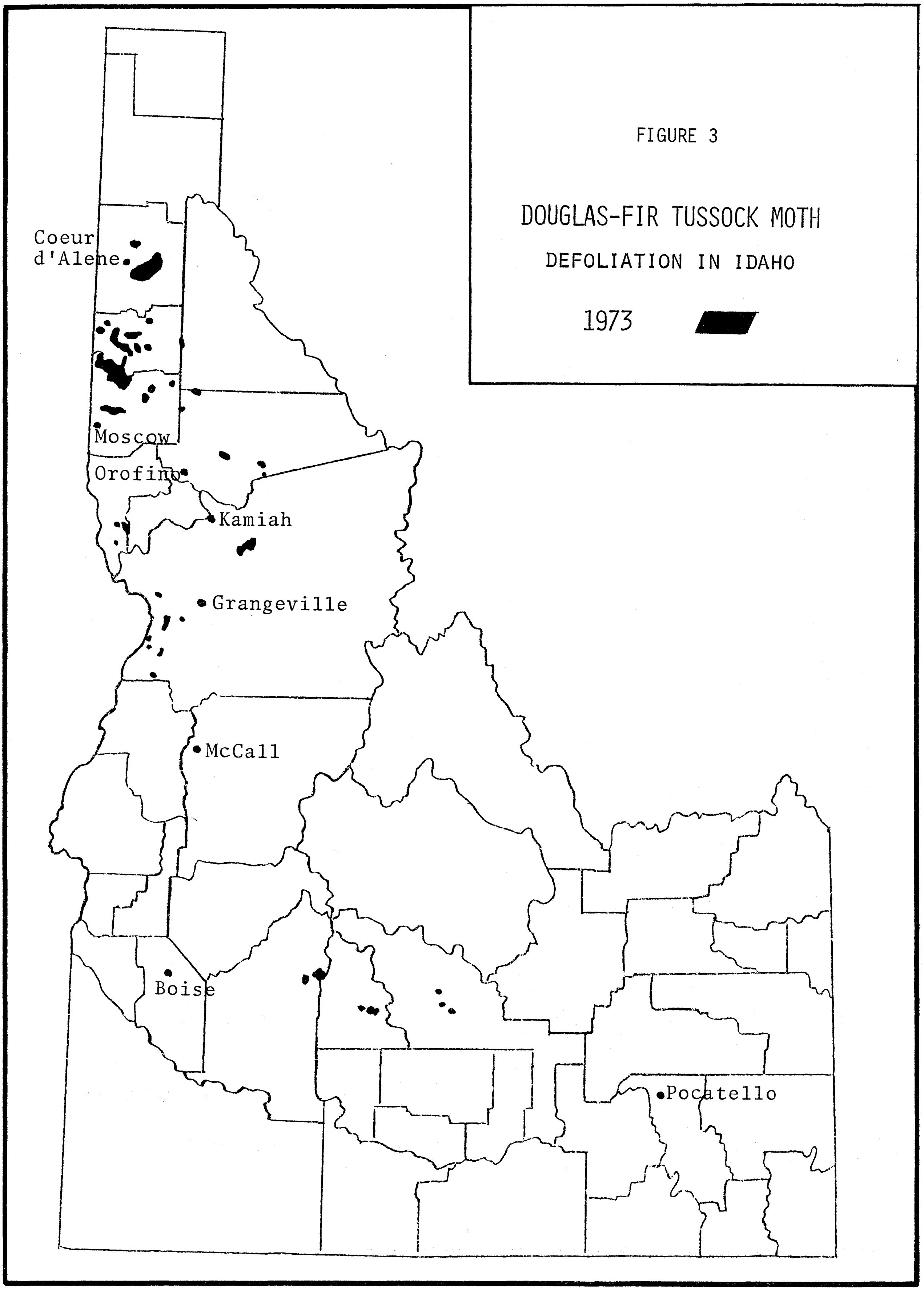


FIGURE 3
DOUGLAS-FIR TUSSOCK MOTH
DEFOLIATION IN IDAHO
1973
Coeur d'Alene
Moscow
Orofino
Kamiah
Grangeville
McCall
Boise
Pocatello

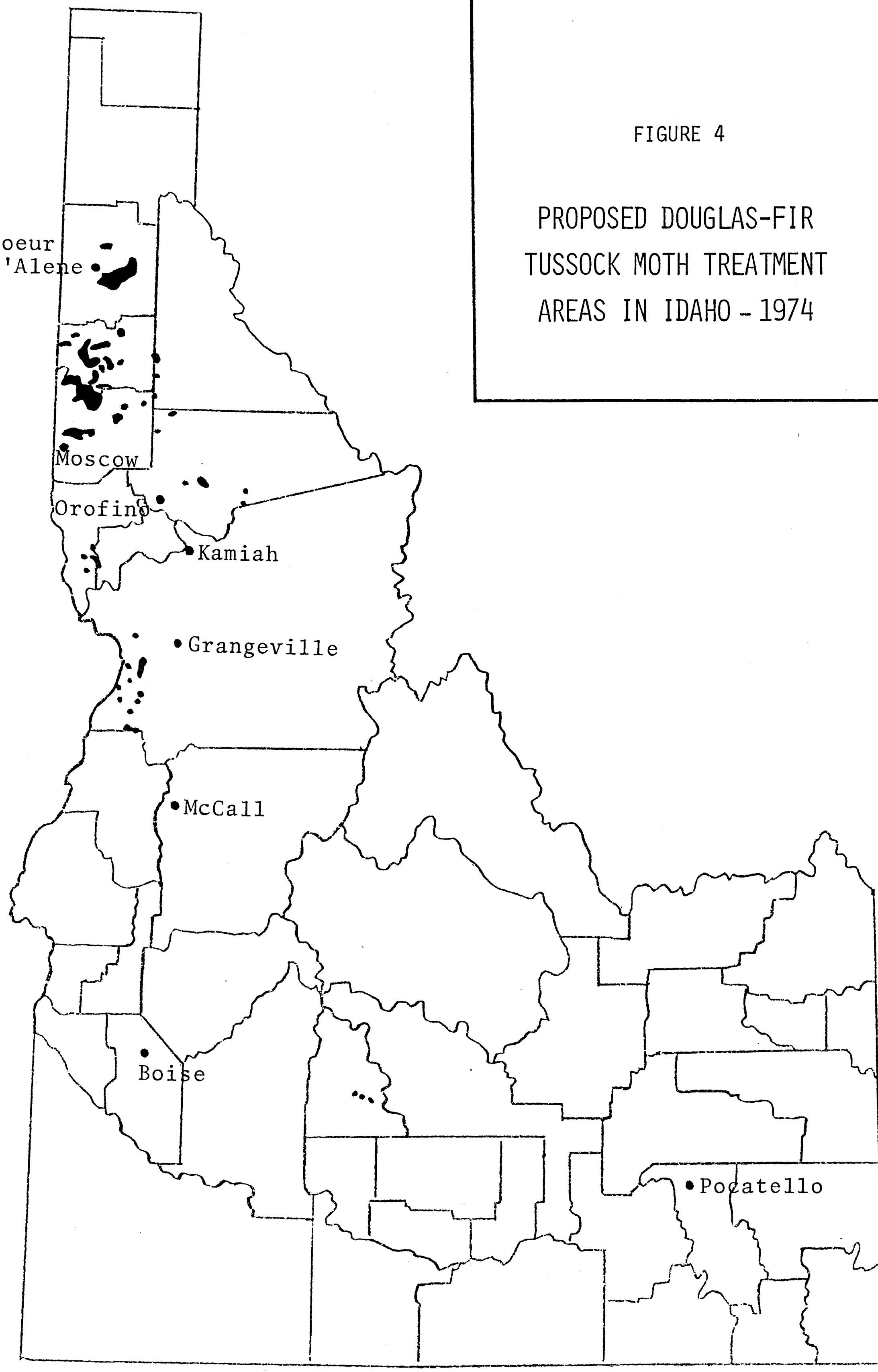



FIGURE 4

PROPOSED DOUGLAS-FIR TUSSOCK MOTH TREATMENT AREAS IN IDAHO - 1974

# THE INSECT

### 1. What is the tussock moth and what does it do to the forests?

The Douglas-fir tussock moth (*Orgyia pseudotsugata*) is one of the most injurious insect pests of Douglas-fir and true firs in the West. The caterpillars hatch in June from egg masses laid the previous fall and feed on foliage until mid-August. When mature, they pupate and emerge shortly thereafter as adult moths. Winged males mate with the wingless females; egg masses are deposited on or near the empty cocoons. The egg masses represent the potential for defoliation the following year.

Populations can develop explosively in an outbreak year. Patches of trees throughout the infested area may be completely stripped of their foliage and killed, while other stands suffer lesser damage.

### 2. What trees are damaged by the Douglas-fir tussock moth?

The insect has three preferred hosts: Douglas-fir, grand fir, and white fir. In the southern part of its range (California, Arizona, Nevada, and New Mexico), white fir is preferred. In the Northwest, where outbreaks have been found only east of the Cascade Mountains, Douglas-fir and grand fir are the primary hosts. After the caterpillars have fed on favored hosts, they may migrate to other species and continue feeding.

Damage has also been recorded on subalpine fir, ponderosa pine, lodgepole pine, western larch, Engelmann spruce, and other trees and understory plants intermingled with the preferred hosts. Ornamental Colorado blue spruce in urban areas is frequently damaged.

### 3. How often do outbreaks occur and how long do they last?

Outbreaks tend to occur at intervals of about 8 to 10 years. Between high population periods, the insect is virtually undetectable in the forest. When an outbreak erupts, it is usually the result of several years of obscure buildup in numbers. In any one location the outbreak usually lasts about 3 years from eruption to complete collapse. Localized epidemic populations frequently appear on ornamental or shade trees several years before an outbreak occurs in the forest.

### 4. Will the insect spread to other parts of the forest?

Because the female moth of the Douglas-fir tussock moth is wingless, it cannot migrate to other areas of the forest to lay eggs. The young larvae, however, are covered with hairs and can be carried by air currents for several miles. The presumed long-distance spread of Douglas-fir tussock moth larvae from infested to uninfested areas during an epidemic is actually the result of localized population building up to epidemic levels "in place."

### 5. What causes the collapse of outbreaks?

The Douglas-fir tussock moth has many natural enemies, including parasites, predators, and disease organisms. Many of these factors, as well as starvation, contribute to the natural decline of outbreaks, but a natural virus seems to be the single factor most commonly associated with collapse the final year. However, the virus usually appears only after trees have been seriously defoliated.

**6. When can the outbreaks be expected to decline?**

Portions of the Blue Mountains outbreak have already declined; other areas will most likely decline in 1974, particularly those which have suffered damage for 2 years. Still other areas, such as the outbreak in northern Idaho which appeared in 1973, may continue for 1 or possibly 2 more years. Actual predictions, however, depend on assessment of overwintering virus incidence and other natural control factors.

**7. Can Douglas-fir tussock moth outbreaks be detected earlier?**

Survey methods for detecting low-level, Douglas-fir tussock moth populations are inadequate. Some new techniques, including the use of sex attractant chemicals (pheromones), appear promising but are not ready for use. The susceptible forest type covers several million acres; costs of monitoring rising populations in this vast area would be prohibitive with present techniques. In the usual endemic situation, populations are almost zero, making detection extremely difficult.

**8. Would earlier detection and treatment prevent spread?**

Generally, no, because outbreak populations develop "in place." Early detection, if followed by early control, would prevent only the damage that otherwise would occur in that particular locality. The amount of area eventually affected because of insect movement out of the development center (by wind or otherwise) is relatively small.

**9. How well can population trends and damage be predicted?**

Once epidemic populations are detected, quite accurate predictions can be made from egg-mass numbers. It is very difficult to make population predictions during the early stages of an outbreak, mainly because of the difficulty of discovering that the insect populations are actually building up in this manner.

Damage prediction is more difficult because of differences in population levels, natural enemies, weather effects, host trees, previous degrees of defoliation, buildup of tree-killing bark beetles, and many other factors.

## EFFECTS OF OUTBREAKS

**10. What does feeding damage do to trees?**

Larvae of the Douglas-fir tussock moth can feed on both the current year's new foliage and the older needles. Heavy larval populations can completely defoliate trees in a single growing season. Trees suffering this degree of defoliation are almost certain to die. The chance of a tree dying decreases with lesser amounts of defoliation. Douglas-fir appears to suffer more damage than grand fir. Many trees that survive partial defoliation are weakened and may succumb to a buildup of bark beetles. Surviving trees exhibit reduced growth for 2 or 3 years, and some suffer top kill. Seedlings and saplings, as well as mature trees, are attacked. There can be significant loss of cone production capability, particularly in the true fir species.

**11. What other kinds of impacts can occur?**

Additional fire hazard is likely and is extreme in heavily damaged areas because of the concentrated, highly flammable material. Hazard will vary with elapsed time, being particularly high during the year of defoliation. It may then decline but increase again

when the snags or top-killed trees become dry and subject to lightning strikes.

Total water yields, low flows, and high flows will likely increase where substantial tree killing has occurred. Debris resulting from the outbreak can enter streams but is unlikely to affect water quality significantly. Salvage logging associated with the outbreak can be controlled to minimize sedimentation.

In general, wildlife habitats will benefit. The principal effect of heavy defoliation and tree killing will be an opening up of the forest canopy, with an increase in light available to understory vegetation. This in turn should promote growth of shrubs, forbs, grasses, and undamaged trees. Ranges for both elk and deer should be enhanced because of the shift from closed canopy, mature stands with a low game carrying capacity to an earlier stage of forest succession with a higher capacity.

On large tree-killed areas, habitats will become less suitable for such species as the red squirrel and for birds of prey, such as the Cooper's hawk.

Recreational values can be affected by tree killing, defoliation, and the presence of large numbers of the insect.

**12. How many acres are now defoliated?**

A total of 689,760 acres suffered varying degrees of feeding injury in eastern Oregon and Washington during 1973 (table 1 and fig. 1). This covers portions of the Blue Mountains, which showed 173,600 acres of defoliation in 1972, and the Colville Indian Reservation and adjoining state and private lands.

Outbreaks were also detected over a significant part of northern Idaho in 1973 – 99,000 acres suffered noticeable defoliation from Coeur d'Alene south to Hells Canyon (fig. 3). Most extensive damage occurred in Benewah and Latah Counties where previous outbreaks were recorded in 1946-48 and 1965-66. Damage also occurred in forested areas south of Lewiston and on the Nezperce National Forest.

Damage of a more localized nature also was found on portions of the Sawtooth National Forest in southern Idaho; near Missoula, Montana; and Las Vegas, Nevada.

**13. How much merchantable timber has been killed and salvaged during the present outbreak?**

The total amount of merchantable timber killed during 1972 and 1973 in Oregon and Washington is estimated to be 1,517 million board feet. Additional volumes were killed, for which no quantitative estimates are available. This includes mortality in inaccessible stands or scattered-tree mortality for which salvage operations were not feasible. There is also no available estimate for losses in young stands which are not of merchantable size.

Since 1972, a total of 690 million board feet of timber has been or soon will be salvaged from Douglas-fir tussock moth infested areas in eastern Oregon and Washington. This volume includes a small amount of green timber, which was removed to make salvage operations economically feasible.

In Idaho, no significant tree mortality has occurred yet, but top killing is common.

**14. What is the outlook for 1974?**

Based on the egg mass surveys completed in the fall of 1973, there is potential for serious defoliation in 1974 on 649,000 acres in Oregon, Washington, and Idaho (table 2 and figs. 2 and 4). If natural factors do not cause a population decline, or if direct control is not undertaken next spring, it is estimated that the volume killed in 1974 on this acreage will be 807 million board feet in Oregon and Washington and 35 million

Table 1

ACRES OF DEFOLIATION BY OWNERSHIP AND DAMAGE CLASS IN 1973:

OREGON AND WASHINGTON

| Area | Acres dead | Acres of defoliation by damage class | | | |
|---|---|---|---|---|---|
| | | Class I | Class II | Class III | Total |
| OREGON | | | | | |
| Blue Mountain Unit: | | | | | |
| Umatilla N.F. | 9,180 | 17,340 | 86,150 | 74,970 | 187,640 |
| Wallowa-Whitman N.F. | 170 | 9,770 | 34,920 | 64,890 | 109,750 |
| BLM (Lookout Mtn.) | 0 | 50 | 1,350 | 170 | 1,570 |
| Umatilla Indian Res. | 0 | 0 | 30 | 30 | 60 |
| State & private | 5,530 | 15,360 | 49,670 | 68,870 | 139,430 |
| OREGON SUBTOTAL | 14,880 | 42,520 | 172,120 | 208,930 | 438,450 |
| WASHINGTON | | | | | |
| Blue Mountain Unit: | | | | | |
| Umatilla N.F. | 2,310 | 9,250 | 78,300 | 76,350 | 166,210 |
| State & private | 80 | 850 | 10,770 | 13,140 | 24,840 |
| Subtotal | 2,390 | 10,100 | 89,070 | 89,490 | 191,050 |
| Wenatchee Unit: | | | | | |
| Wenatchee N.F. | 0 | 320 | 40 | 120 | 480 |
| State & private | 0 | 840 | 200 | 200 | 1,240 |
| Subtotal | 0 | 1,160 | 240 | 320 | 1,720 |
| Okanogan Unit: | | | | | |
| State & private | 0 | 2,080 | 750 | 1,020 | 3,850 |
| Colville Unit: | | | | | |
| Colville N.F. | 0 | 0 | 0 | 160 | 160 |
| Colville Indian Res. | 0 | 2,810 | 12,200 | 21,160 | 36,170 |
| State & private | 0 | 2,560 | 1,080 | 11,680 | 15,320 |
| Subtotal | 0 | 5,370 | 13,280 | 33,000 | 51,650 |
| N.E. Washington Unit: | | | | | |
| State & private | 0 | 840 | 200 | 2,000 | 3,040 |
| WASHINGTON SUBTOTAL | 2,390 | 19,550 | 103,540 | 125,830 | 251,310 |
| OREGON AND WASHINGTON TOTAL | 17,270 | 62,070 | 275,660 | 334,760 | 689,760 |

NOTE: See next page for definitions of damage classes.

Table 1

## ACRES OF DEFOLIATION BY OWNERSHIP AND DAMAGE CLASS IN 1973: IDAHO AND MONTANA

| Area | Acres dead | Acres of defoliation by damage class | | | |
|---|---|---|---|---|---|
| | | Class I | Class II | Class III | Total |
| NORTHERN IDAHO | | | | | |
| Nezperce Unit: | | | | | |
| Nezperce N.F. | 0 | 1,000 | 0 | 22,000 | 23,000 |
| Lewiston Unit: | | | | | |
| State & private | 0 | 500 | 1,000 | 2,500 | 4,000 |
| Orofino Unit: | | | | | |
| State & private | 0 | 0 | 120 | 0 | 120 |
| St. Joe Unit: | | | | | |
| St. Joe N.F. | 0 | 1,000 | 3,000 | 16,000 | 20,000 |
| State & private | 0 | 4,000 | 3,500 | 42,500 | 50,000 |
| Subtotal | 0 | 5,000 | 6,500 | 58,500 | 70,000 |
| Coeur d'Alene Unit: | | | | | |
| Coeur d'Alene N.F. | 0 | 200 | 800 | 800 | 1,800 |
| State & private | 0 | 0 | 30 | 50 | 80 |
| Subtotal | 0 | 200 | 830 | 850 | 1,880 |
| SOUTHERN IDAHO | | | | | |
| Sawtooth Unit: | | | | | |
| Sawtooth N.F. | 0 | 2,600 | 8,100 | 0 | 10,700 |
| IDAHO SUBTOTAL | 0 | 9,300 | 16,550 | 83,850 | 109,700 |
| MONTANA | | | | | |
| Lolo Unit: | | | | | |
| Lolo N.F. | 0 | 25 | 25 | 0 | 50 |
| State & private | 0 | 10 | 290 | 0 | 300 |
| MONTANA SUBTOTAL | 0 | 35 | 315 | 0 | 350 |
| IDAHO-MONTANA TOTAL | 0 | 9,335 | 16,865 | 83,850 | 110,050 |

Definitions

Dead - Areas of heavy mortality from defoliation in 1973. Includes areas that have been salvage logged.

Class I - Fifty percent or more of the host type has been completely defoliated.

Class II - Fifty percent or more of the host type has at least the top quarter of the crown completely defoliated.

Class III - Host type has defoliation visible from survey aircraft. The current year's foliage has been removed on most trees but less than a quarter of the crown has been completely defoliated.

board feet in Idaho.

A considerable amount of the area threatened is outside the area now visibly defoliated, but it contains heavy concentrations of egg masses.

An additional undetermined volume may be killed by bark beetles attacking trees weakened by defoliation.

**15. How does the Douglas-fir tussock moth affect human health?**

Many people suffer a skin allergy or respiratory reaction on exposure to larvae and cocoons. During 1972-73, the Oregon State Health Division investigated the impact on humans working in the infestation area and reported that a significantly increased health hazard occurred, particularly during hot, dry weather. Seventy-five to 90 percent of the people working in infested areas experienced some irritation (itching, skin rash) due to the tussock moth hairs. If the infestation continues next year, it is expected that approximately 50 percent of this group will lose working time and may require medical assistance.

## ALTERNATIVES

**16. What alternatives does the resource manager have to deal with Douglas-fir tussock moth infestations?**

The resource manager basically has three alternatives available to him to cope with the Douglas-fir tussock moth problem:

a. Do nothing. Accept the consequences of defoliation and rely on natural enemies, such as the virus, to end the outbreaks.
b. Where accessible, salvage merchantable size trees which have been killed or severely weakened. Rehabilitate sites of heavy mortality to get a new, healthy stand established.
c. Apply toxic chemicals to infested stands when the larvae are feeding, to save foliage and control the outbreak. DDT is the only chemical proven effective against outbreaks of Douglas-fir tussock moth. This chemical was used in Idaho, Oregon, and Washington in 1947 and 1965 and in California in 1956 and 1965. However, virtually all registered uses of DDT have been cancelled.

**17. Have chemicals other than DDT been tested against the Douglas-fir tussock moth?**

A wide range of chemicals has been tested in the laboratory against Douglas-fir tussock moth by the Forest Service's Pacific Southwest Forest and Range Experiment Station at Berkeley, California, in an attempt to seek a safe, effective substitute for DDT. Four of the more promising – Zectran, Dylox, Sevin-4-Oil, and Bioethanomethrin – were field tested during 1973 on 400- to 500-acre plots in eastern Oregon and Washington. Results showed that all the chemicals killed considerable numbers of tussock moth larvae, but none reduced the population sufficiently to prevent severe defoliation and tree mortality.

A test of Sevin-4-Oil also was conducted in Idaho in 1973 in an area of first-year defoliation. Although population reductions were comparable to those from the tests in Oregon and Washington, the populations sprayed were much lower; thus, the treatment resulted in more foliage protection.

Table 2

AREAS OF POTENTIALLY SERIOUS DEFOLIATION IN 1974

| Area | Acres |
|---|---|
| OREGON AND WASHINGTON | |
| Blue Mountain Unit: | |
| Umatilla National Forest | 114,670 |
| Wallowa-Whitman National Forest | 132,147 |
| State and private | 134,400 |
| Subtotal | 381,217 |
| Colville Unit: | |
| Colville Indian Reservation | 106,215 |
| Private | 6,636 |
| Subtotal | 112,851 |
| Northeast-North Central Washington Unit: | |
| State and private | 11,510 |
| Okanogan Unit: | |
| State and private | 700 |
| OREGON AND WASHINGTON SUBTOTAL | 506,278 |
| NORTH IDAHO | |
| Coeur d'Alene Unit: | |
| State and private | 4,172 |
| Forest Service | 29,966 |
| Subtotal | 34,138 |
| St. Joe Unit: | |
| Coeur d'Alene Indian Reservation | 4,500 |
| State and private | 45,352 |
| Forest Service | 14,927 |
| Subtotal | 64,779 |
| Clearwater Unit: | |
| State and private | 2,686 |
| Forest Service | 1,747 |
| Subtotal | 4,433 |
| Lewiston Unit: | |
| State and private | 4,762 |
| Nezperce Unit: | |
| State and private | 1,312 |
| Forest Service | 32,189 |
| Subtotal | 33,501 |
| North Idaho Subtotal | 141,613 |
| SOUTH IDAHO | |
| Sawtooth Unit: | |
| State and private | 1,200 |
| South Idaho Subtotal | 1,200 |
| IDAHO SUBTOTAL | 142,813 |
| GRAND TOTAL | 649,091 |

Specific conclusions from the tests are: (a) all the chemicals killed considerable numbers of tussock moth larvae, but none reduced the populations sufficiently to prevent severe defoliation or tree mortality, (b) none of the materials tested in 1973 is ready for operational use in 1974, and (c) all appear sufficiently promising to warrant further laboratory and field testing.

**18. Is biological control feasible?**

Two microbial agents, the natural virus of the tussock moth and a bacterium, *Bacillus thuringiensis (B.t.)*, were tested against Douglas-fir tussock moth in 1973. These materials were applied by helicopter to 20-acre plots on the Wallowa-Whitman National Forest.

Results of these tests indicate that both *B.t.* and the virus hold good potential as controls for Douglas-fir tussock moth. However, additional laboratory research followed by pilot control tests is needed before either material can be recommended for operational use against the Douglas-fir tussock moth. Principal problems yet to be solved are (a) mass production of the virus, (b) development of suitable techniques for mixing and handling large quantities of these materials, and (c) development of formulations that can be used in conventional spray systems. Sufficient virus is not available to treat a large area in 1974. Only a few laboratories in the United States can produce virus materials; their capacity is now quite limited. *B.t.*, although more available, is not ready for operational use without further development of the special formulations required for use against the tussock moth.

**19. Why has the use of DDT been judged objectionable?**

Three properties make DDT's use objectionable: its persistence in the environment, its widespread distribution and accumulation in nontarget organisms through the food chain, and its broad spectrum of biological activity.

**20. Will DDT control tussock moth?**

Yes, based on previous control projects, DDT is very effective. This has also been verified many times in laboratory tests. Field checks of northern California projects showed 98 to 100 percent larval mortality within 2 weeks after spraying.

**21. Will DDT kill Douglas-fir tussock moth larvae fast enough to save new foliage?**

Yes, if applied to very young larvae.

**22. When will the treatments have to be applied to be most effective?**

To be most effective, the treatment must start within about 3 days after 60 percent of the egg masses have begun to hatch. It can be applied during about a 10-day period after this date. DDT can be applied later in the development period, but the longer this is delayed the higher the risk of foliage loss.

**23. How much DDT would control the Douglas-fir tussock moth and what would be the costs of application?**

Three-fourths pound of DDT per acre. Cost of application would be approximately $4 per acre.

## DISPOSITION AND BIOLOGICAL IMPACTS OF DDT

**24. How much DDT would be applied in the states of Oregon, Washington, and Idaho in a tussock moth control operation in 1974?**

For every 100,000 acres treated, 75,000 pounds of DDT would be applied.

**25. What are the U.S. and world uses of DDT?**

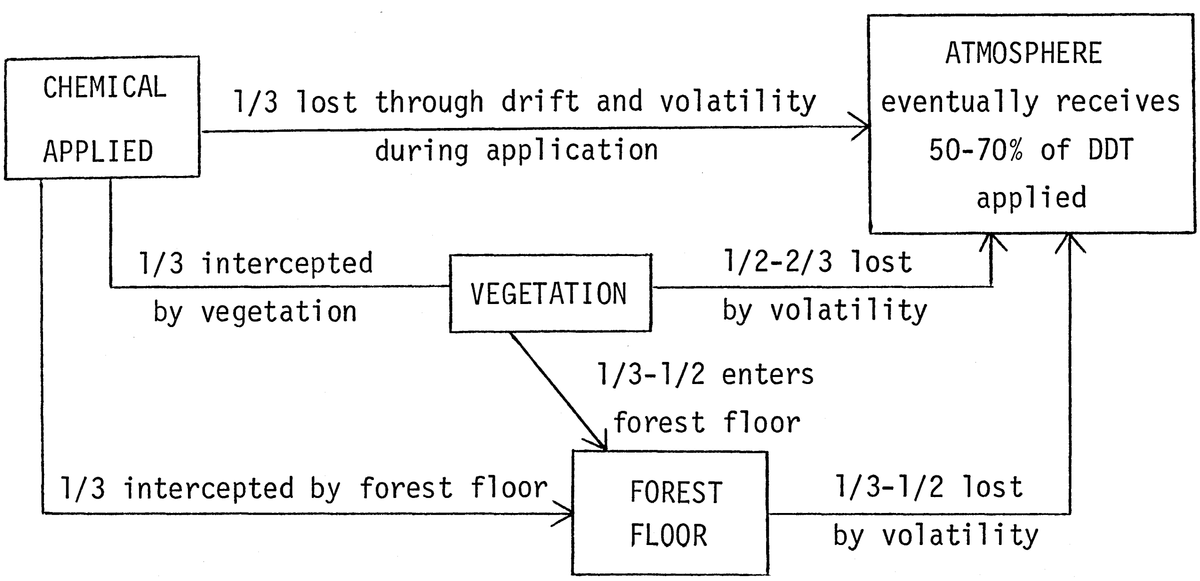
U.S. Production and Consumption of DDT
(millions of pounds)

| Year | Production | Consumption | Forestry Uses |
|---|---|---|---|
| 1955 | 99.7 | 61.8 | 3.5 |
| 1960 | 160.0 | 70.1 | 0.4 |
| 1965 | 130.8 | 53.0 | 0.2 |
| 1970 | 59.3 | 24.0 | 0.0 |
| 1972 | (unknown) | 5-10 (est.) | 0.0 |
| 1973 | (unknown; export only) | 0.1 - 0.3 (est.) | 0.0 |

The differences between U.S. production and consumption represent export. Figures for world consumption are not readily available. Up to 1960, U.S. production probably represented most of the world consumption, but since then production outside the U.S. has increased steadily. The World Health Organization reports about 20 million pounds of DDT were used in 1972 for malaria control.

**26. What happens to DDT during aerial application to forests?**

As a rule of thumb, about one-third is lost in drift and volatilization, one-third is intercepted by vegetation, and one-third falls to the forest floor; but these volumes are markedly influenced by atmospheric and spray application factors and vegetation density.



**27. What happens to DDT lost to the atmosphere?**

Some may undergo photochemical decomposition, but most probably falls to the earth in fine particles of spray or is adsorbed to dust particles, which are the condensation nuclei for precipitation. DDT adsorbed on dust or in the vapor phase and minute DDT particles may contribute to the "global distribution of DDT."

**28. What happens to DDT intercepted by vegetation?**

Some of the DDT deposited on vegetation is vaporized during the first few days and weeks after application. The remaining portion on leaves and conifer needles gradually drops to the forest floor, through leaf fall for about 5 months after application and through needle fall for about 3 years. After a Douglas-fir tussock moth control project near Burns, Oregon, in 1965, DDT residues in grass and shrubs declined from 75 ppm (parts per million) 4 months later to 1 ppm 1 year later.

**29. What happens to DDT in the forest floor?**

About half the DDT reaching the forest floor during the Burns project was gone 3 years later. If these residues continued to follow classical residue loss patterns, one-quarter would remain after 6 years and one-eighth after 9 years. At Burns, 26 percent of the application was recovered from the forest floor 1 month after application, and an additional 6 percent entered in freshfall litter in the succeeding 36 months after application. There was essentially no movement to mineral soil or ground water. Volatilization and degradation are probably responsible for the loss, but the relative importance of each is not known. Volatilization may account for much of the loss in the first few months after application.

These residues are then taken up by organisms that consume forest litter. Although these organisms degrade some of the DDT to harmless metabolites, some of the DDT and the metabolite DDE (which is not harmless) is stored in their bodies and transferred to still other organisms that prey upon them.

**30. How much DDT gets into streams?**

In stream and lake environments, DDT residues can result from both the initial deposit and input to the runoff for several years. In spraying, every attempt should be made to leave untreated areas adjacent to streams and lakes to reduce or eliminate these effects. Use of generous buffer strips is necessary to minimize impact of spray materials on stream surfaces and also to act as a filter for soil particles, which may be coated with DDT or are suspended in surface water flowing from treated areas. In steep canyons, however, it is difficult to cover the trees yet miss the streams entirely.

**31. What harmful effects of DDT could there be to fish and aquatic organisms?**

Fish can be immediately affected if the terrain, wind, current, or other circumstances permit direct contamination of the body of water. Very young fish are the most susceptible, and their mortality could vary from no kill at all to a moderate or even severe kill, depending on spraying conditions. Another immediate effect could be a kill of aquatic insects. The loss of this fish food would result in fish leaving the affected area. The DDT level in fish can remain at 1 part per million, or more, for 1 to 4 years. The residue levels in fish are highly variable, depending on the initial input, the nature of the body of water, the nature of the watershed, and several other factors.

The most important effect on fish following a DDT application would be in the winter months when there are low temperatures and a low food supply and the fish are

utilizing their stored fat tissues. Fish losses that occur at this time would be greater than those that occurred immediately after treatment. Effects on fish are subject to a higher degree of variability than those for mammals or birds because the DDT exposure is dependent on the success achieved in protecting the streams.

**32. How long would significant residues of DDT persist in large game and domestic animals?**

They would persist at biologically significant levels for less than 1 year in animals that feed on vegetation. Deer or cattle that are harvested or slaughtered in the fall of the treatment year can be expected to have DDT residues in their body fat that will average 1 to 5 parts per million. However, some individual deer or cattle can be expected to carry more than the EPA-permitted tolerance (in marketed meats) of 7 ppm in their body fat in the fall of the treatment year. This is unlikely to create any health problems but might cause legal problems if slaughtered cattle exceed this tolerance level.

**33. How much DDT might be found in small animals, like rabbits, shrews, song birds?**

Shrews and insectivorous birds may contain elevated levels of DDT (1 to 5+ ppm) for several (1 to 8) years. DDT residues in seed and vegetation eating animals, like mice and rabbits, will increase for a short time after application but will return to nearly normal levels within a year.

**34. Specifically, what harmful effects of DDT would there be on small animals and their predators?**

Acute toxic effects are not expected to occur in most of these animals. However, 10 to 20 percent of the population can have DDT residues which are several times greater than average, and these individuals would sustain the greatest proportion of effect. Reduced reproduction and altered physiological and hormonal levels may occur in birds of prey and other predators whose diets regularly include these individuals.

**35. Is DDT harmful to nontarget insects in the treatment area?**

Yes. Many insect species are killed by DDT, including beneficial parasites and predators. After the Burns Project in eastern Oregon and some spruce budworm projects in Montana, natural enemies of spider mites were killed. This permitted buildup of the mites and resulted in some defoliation for about 1 year.

**36. Is DDT toxic to soil micro-organisms or soil insects?**

DDT is not toxic to soil micro-organisms at concentrations which would occur in the forest. There would probably be some impact on soil insects, but the extent has not been measured. Any effect would likely be of very short duration.

**37. Does DDT cause thin eggshells?**

Yes, it can. Thin eggshells have been induced experimentally by feeding DDT or its metabolites to three types of birds. There is a correlation between the DDE (biologically active DDT metabolite) content of eggs and eggshell thickness for some species in nature. DDT alone may not be responsible for eggshell collapse, but it may be a contributing factor in combination with other environmental stresses such as presence of man, changes in diet, or other chemicals like PCB or mercury. Birds of prey are the organisms most likely to be affected by DDT, because they occupy a high

trophic level in the food chain and have a low reproductive potential. Effects on eggshell thinning from a single application of DDT on a forested area are not quantitatively known but may occur in certain birds of prey, based on their present body burdens of DDT and anticipated intake.

## THE DECISION FOR OR AGAINST CONTROL IN 1974

### 38. How will the decision to recommend for or against control in 1974 be made?

The systematic egg mass survey conducted in the fall of 1973 will provide the basis for this decision. This survey consisted of counting new egg masses on sample plots on almost every section (640 acres) of land showing evidence of feeding injury or likely to have an insect population next year. If egg mass counts and related entomological data in a section meet criteria established by survey and research entomologists, that section will be included in a proposed control unit.

### 39. What are the criteria that will be used in making control recommendations?

Entomological data are the basic criteria and include: (a) presence of new egg masses, (b) new egg mass density expressed as egg masses per thousand square inches of foliage, (c) ratio of new to old egg masses, (d) incidence of natural virus, and (e) spring larval population density.

A new egg mass density of one-tenth egg mass per 1,000 square inches of foliage is the basic criterion for consideration of control. Another criterion is a ratio of new to old egg masses which exceeds 1 to 1, indicating an increasing population. Areas which contain small numbers of new egg masses, but are adjacent to areas of potentially high infestations, would be included in order to make control units conform to natural topographic features (such as ridge tops).

Laboratory observations will be made during the winter months on egg masses collected from sample plots to measure incidence of natural virus, egg parasitism, and egg viability. Areas suffering negligible or light defoliation will be excluded from control units if incidence of virus infection equals or exceeds 30 percent. Areas suffering moderate to heavy defoliation, where the risk of another year's feeding would result in extensive losses, would require a virus infection level of 50 percent before they would be excluded from proposed control units.

A larval population of 20 insects per 1,000 square inches of foliage is the level at which significant foliage injury occurs. Egg parasites, winter stress, and other natural phenomena influence spring egg viability and resulting number of larvae. These will be measured by laboratory rearing. Any area with less than 20 surviving larvae per 1,000 square inches of foliage will be excluded from further consideration of control.

### 40. What amount of defoliation is acceptable?

This depends greatly on the management objectives for an area (e.g., timber, Christmas trees, recreation). Tree mortality and top kill are not acceptable under most management objectives. Top kill causes loss of the cone-producing area (especially in true fir), creates fire and safety hazards, weakens the tree, making it susceptible to attack by bark beetles, and provides an entry for disease-causing fungi. The loss of only the new (current year) growth is acceptable in most cases where there has been no previous defoliation.

**41. Who will decide if an infested area will be treated?**

If emergency use of DDT is authorized, the final decision to treat or not to treat an area will be made by the individual responsible for its management. Management objectives, sensitivity of an area, such as for fish or water supplies, as well as the entomological criteria described above, will be used by the land manager to make this decision. For example, an area managed for Christmas tree production can tolerate virtually no defoliation; consequently, this type of area would be more inclined toward treatment than an area managed for timber resources. Primitive and wilderness areas would probably not be treated regardless of tussock moth density unless they threaten adjacent stands which are under multiple use management.

**42. Who will make the decision to reapply or not to reapply to the EPA for emergency use of DDT?**

The final decision to reapply to the EPA for the emergency use of DDT probably will be made by the Secretary of Agriculture in consultation with other federal forest managing agencies, state forestry agencies, private owners, pest action councils, and others. An environmental impact statement prepared by the U.S. Forest Service and cooperating federal and state agencies would be the supportive document for reapplication to use DDT.

**43. What additional data would be collected in the field before the final decision to treat?**

Egg masses would be tagged in early May in the proposed treatment areas and checked periodically to determine egg hatch date. At the same time and on each visit, observations would be made to verify the predicted population. This would include a determination of whether frost had significantly damaged the new growth and whether there had been any significant loss or damage to the egg masses.

**44. From whom does the private landowner obtain advice and assistance?**

From the state agency that has the responsibility for forest insect control. For example, in Washington, it is the Washington State Department of Natural Resources; in Idaho, the Idaho Department of Public Lands; and in Oregon, the Oregon State Department of Forestry.

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